



Sensitivity of Aerosol Multi-Sensor Daily Data Intercomparison to Level 3 Dataday Definition

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Why people use Level 3 products?

- Satellite Level 2 data are difficult to work with because of:
 - Complex formats
 - Complicated projection (swath)
 - Data volume
 - Number of files
- Level 3 products are widely used by modelers, application users, climate change scientists
- Level 3 data **are easy to use** ... but also **are easy to misuse**



Why something might go wrong with Level 3 products?

- Usually, Science Teams are tasked to produce & validate Level 2 data
- Level 3 products are treated mostly as just imagery, to assess gross features and variability of geophysical parameters
- Usability of L3 data usually is not a high priority
- L3 data are constructed differently for different instruments
- L2 errors usually are not propagated to L3
- At best, standard deviations (mostly reflecting variability within a grid box), sometimes pixel counts and quality histograms are provided
- The L3 “validation”, in most cases, is done by consistency checking and comparing with L3 data from other sensors or models
- No consistent efforts to characterize & quantify L3 uncertainties



So, what do we need to do?

Despite Science Teams/Data Providers not encouraging using L3, these products are widely used, so their quality and differences between them need to be addressed

- **Instrumental issues:** measurement precision, differences in calibration and instrument sensitivity, changes or drift in calibration or sensitivity over time, etc.
- Fundamental differences in the **retrieval algorithm method (multispectral vs. multi-directional)** and **assumptions:** aerosol models employed, wavelengths used, cloud filtering, surface reflection handling
- **Observational issues:** rapidly varying cloud cover, viewing angles and conditions, time(s) of observation, changing surface characteristics, etc.



Differences in L3 from different sensors, cont.

When comparing data from different sensors, it is important to understand and (where possible) consistently process the data.

L3 data processing:

- **Spatial and temporal binning (L2→L3 daily):**
 - Measurements (L2 pixels) from one or more orbits can go into a single grid cell → different within-grid variability
 - Different weighting: pixel counts, quality
 - Thresholds used, i.e., > 5 pixels
- **Data aggregation (L3D → L3monthly → regional → global):**
 - Weighting by pixel counts or quality
 - Thresholds used, i.e., > 2 days

While these algorithms have been documented in ATBD, reports and papers, the typical data user is not immediately aware of how a given portion of the data has been processed.



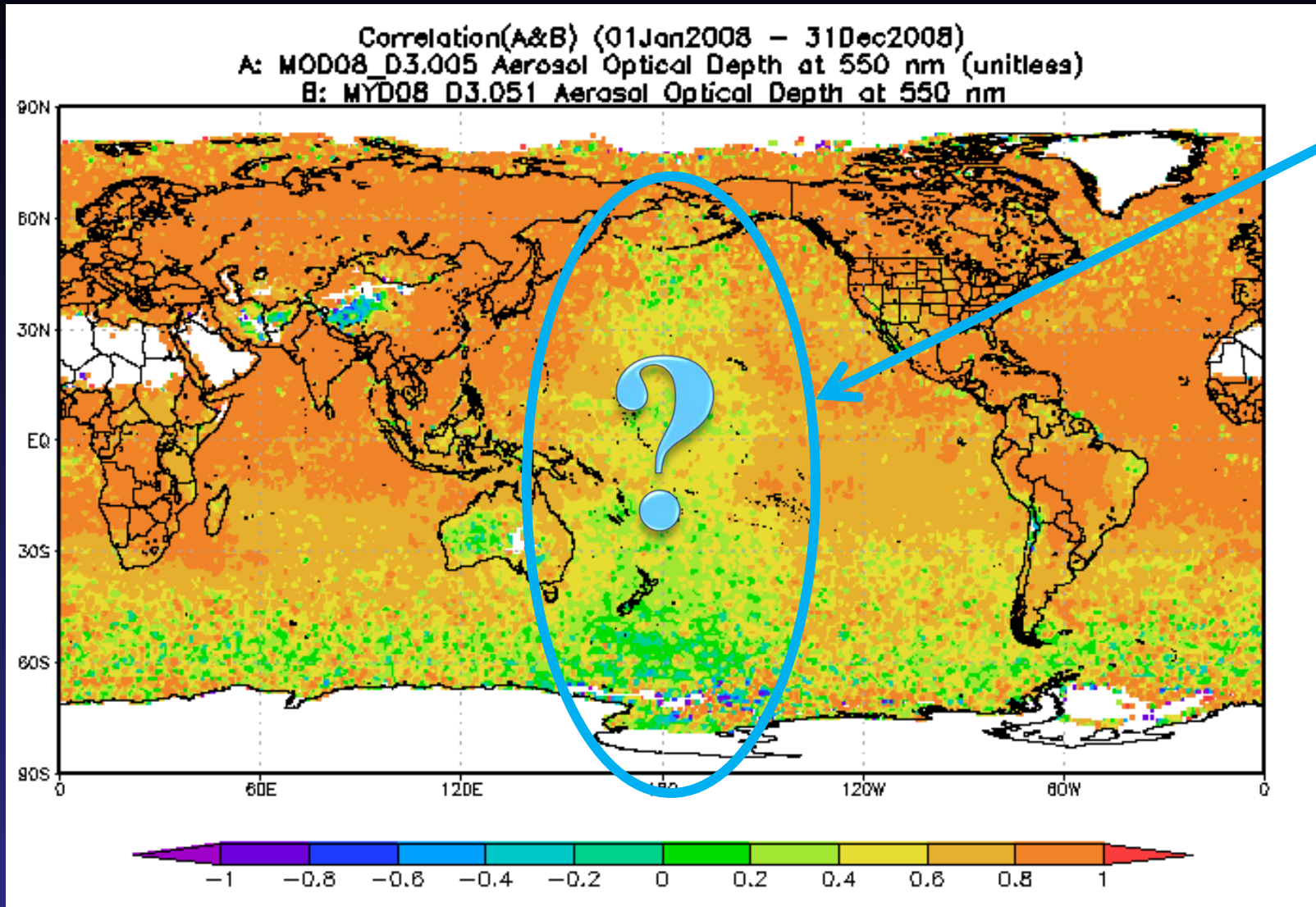
Level 3 dataday definition

Here we address one more aspect of potential incompatibility between Level 3 data coming from different sensors: the dataday issue.

Let's compare Level 3 daily data between MODIS-Terra and MODIS-Aqua:



MODIS vs. MODIS



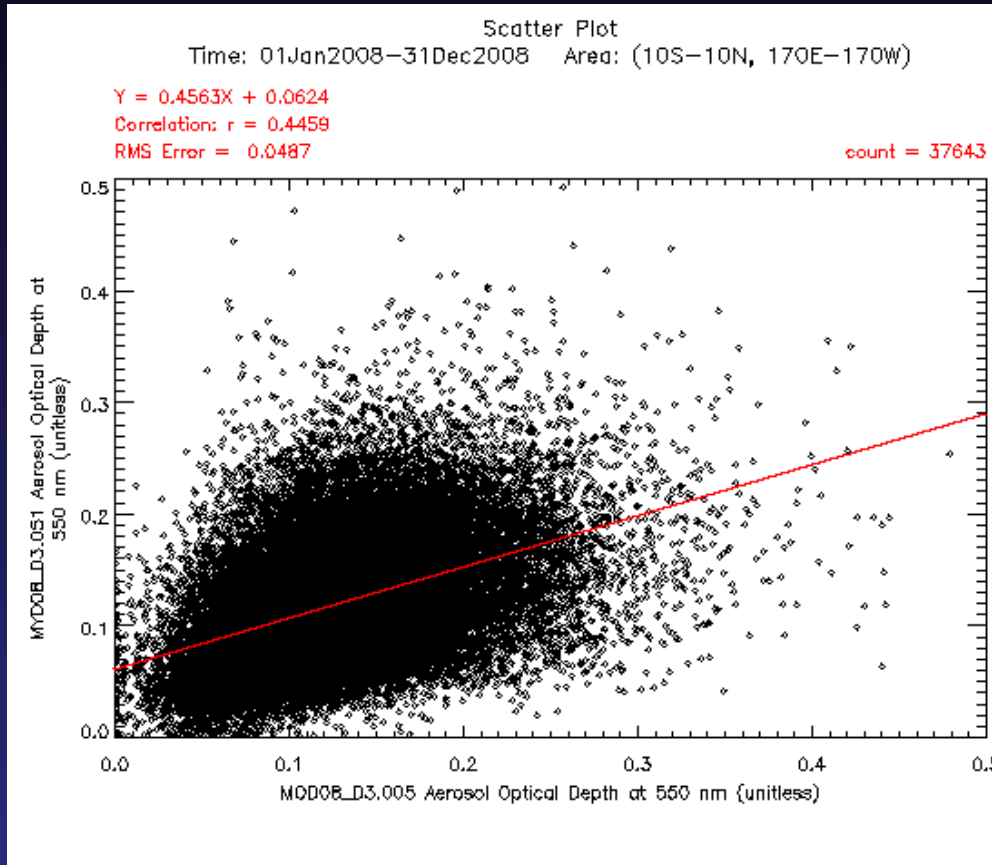
MODIS-Terra vs. MODIS-Aqua: Map of AOD temporal correlation, 2008



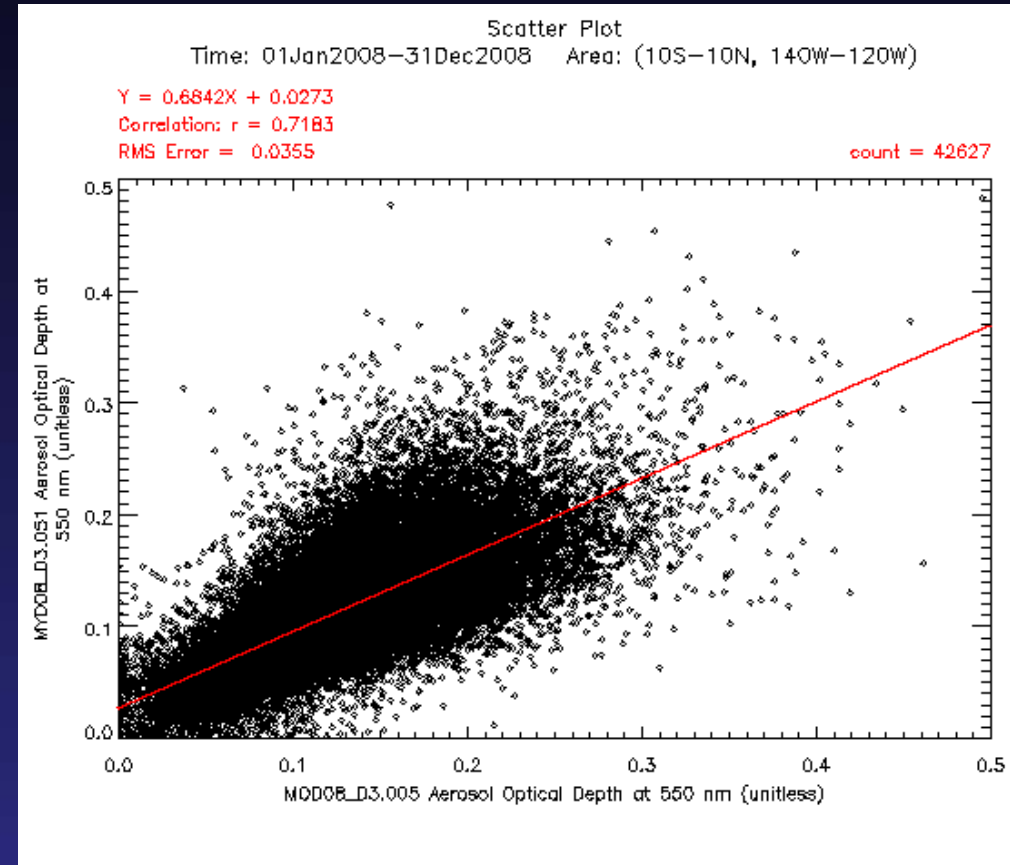
AOD MODIS Terra vs. Aqua in Pacific

Over the dateline

Away from the dateline



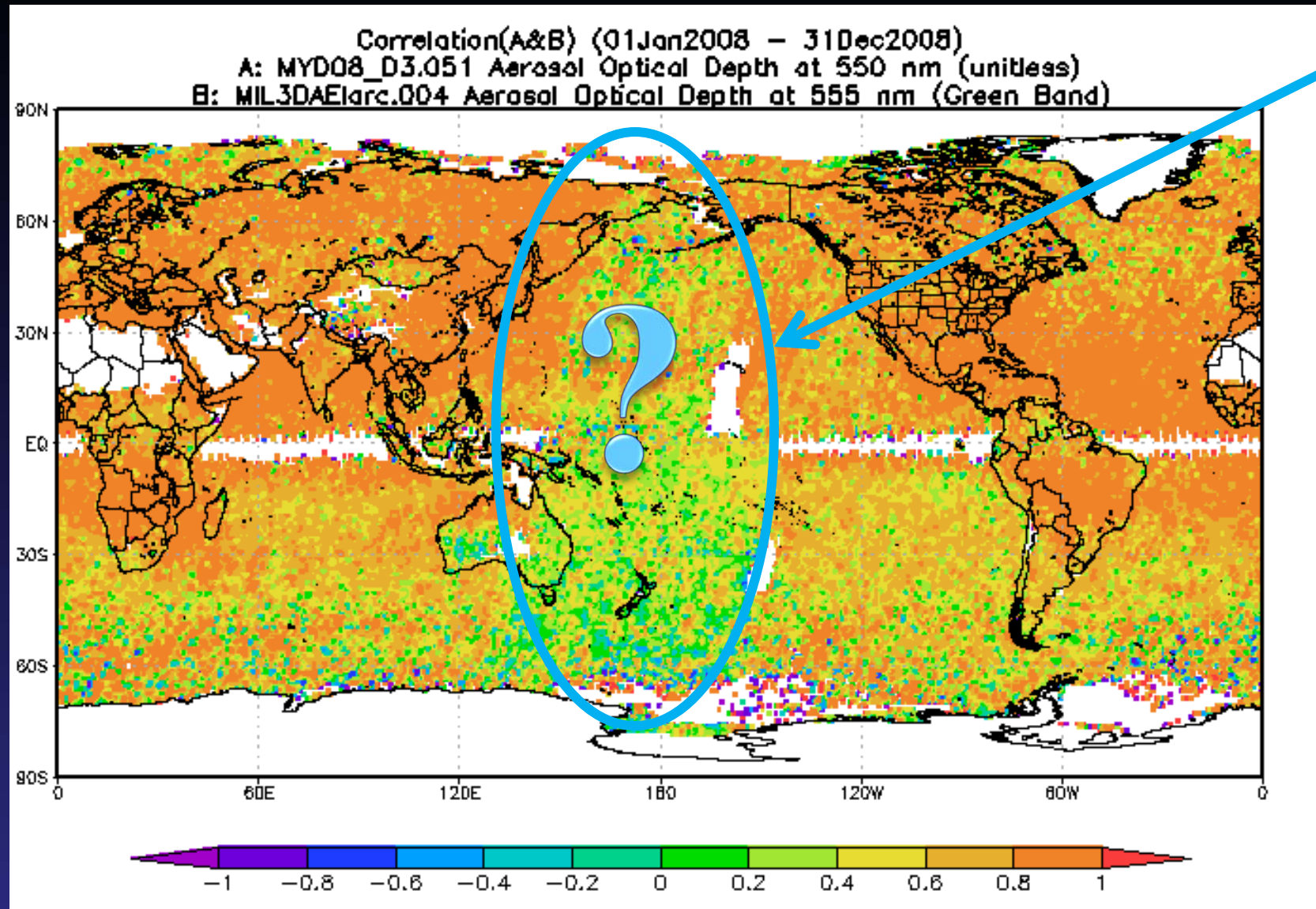
$R^2 = 0.45$
RMS = 0.05



$R^2 = 0.72$
RMS = 0.036



AOD Aqua MODIS vs MISR correlation map

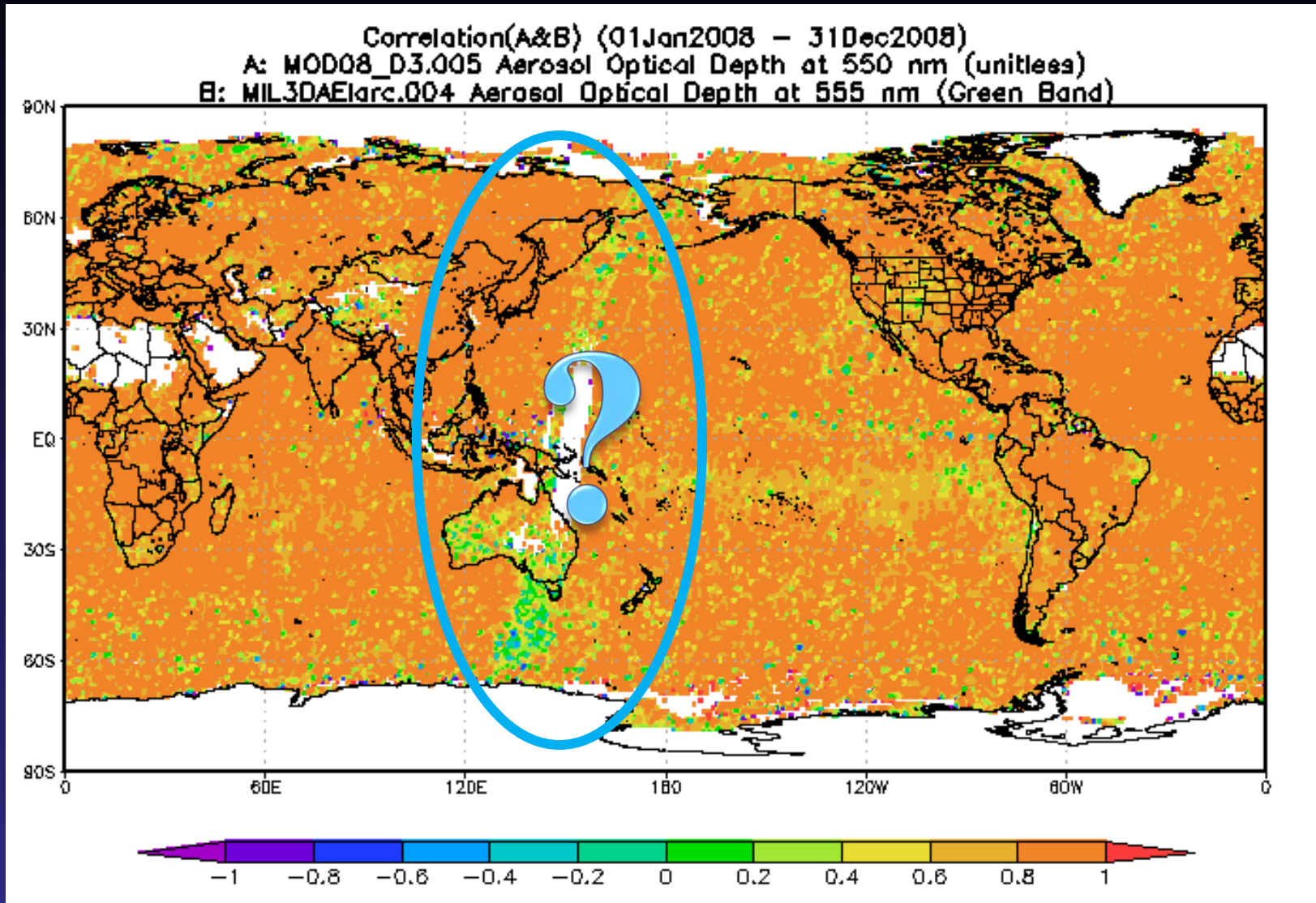


AOD Aqua MODIS vs MISR correlation map for 2008

Note: It is basically the same sensor but on different platform,
but correlation is not that good



MODIS vs. MISR on Terra



MODIS-Terra vs. MISR-Terra: Map of AOD temporal correlation

Note: a very good correlation globally besides a narrow area



MODIS Atmos. Data day definition

Level 3 daily products are generated by binning Level 2 data belonging to one day onto a certain spatial grid according to a dataday definition.

Dataday might be different for different sensors and sometimes even for the same sensor but defined by different teams.

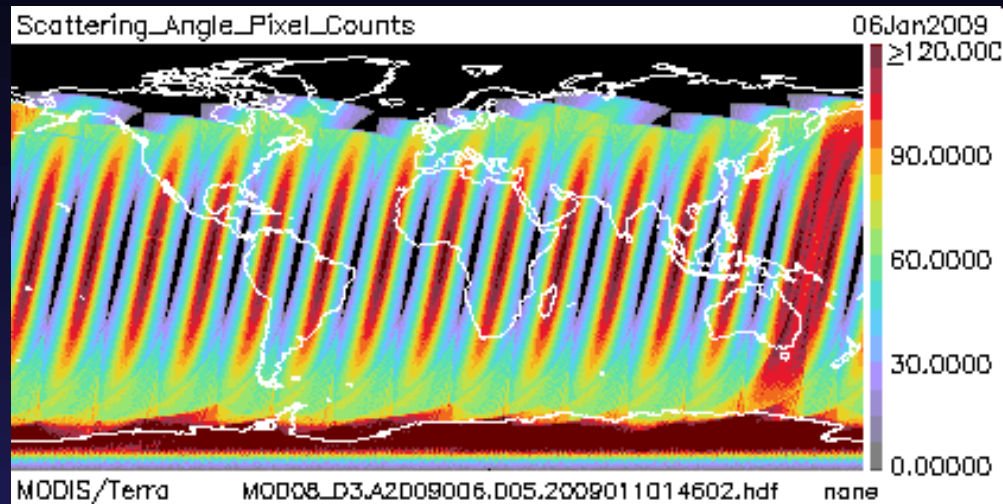
MODIS Atmospheric products (from MODIS L3 ATBD):

The Daily L3 product contains statistics computed from a set of L2 MODIS **granules** (HDF files) that span a 24-hour (00:00:00 to 23:59:59 UTC) interval. In the case where a L2 parameter is only computed during the daytime, then only daytime files are read to compute the L3 statistics.

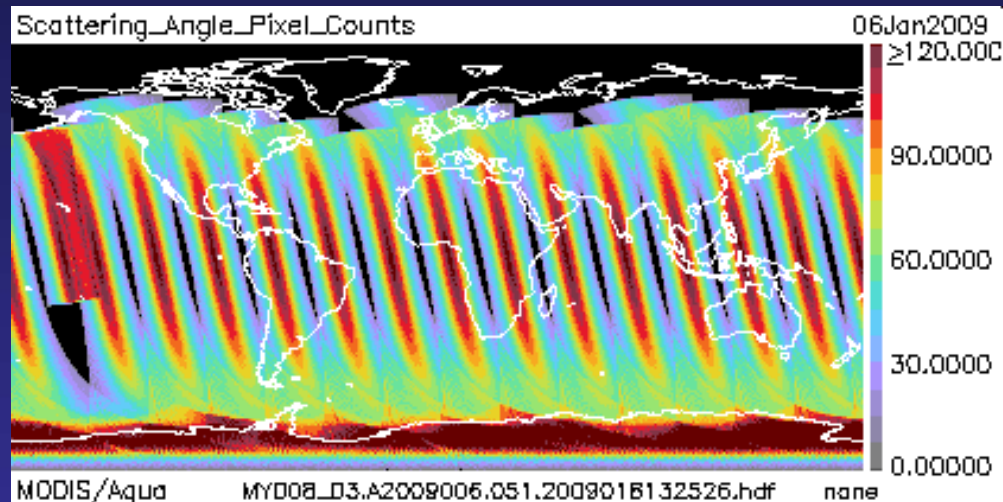


Orbit Time Difference for Terra and Aqua 2009-01-06

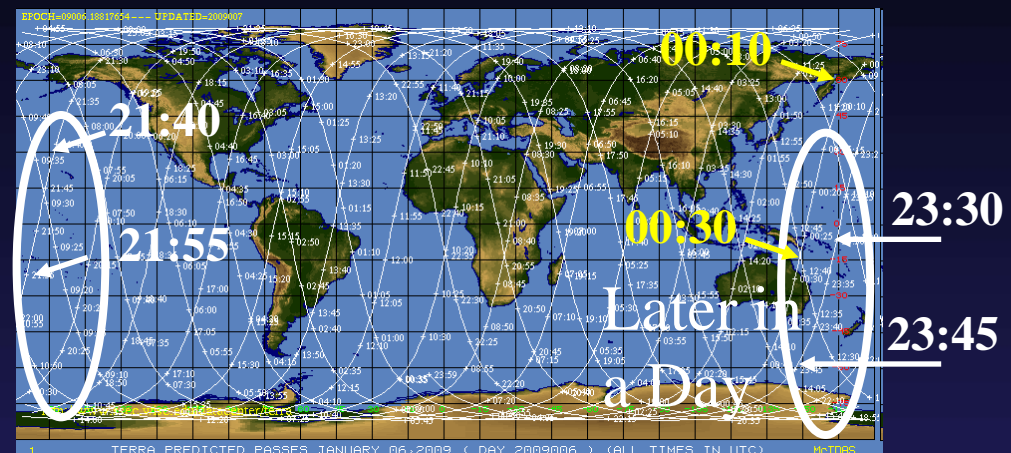
Terra



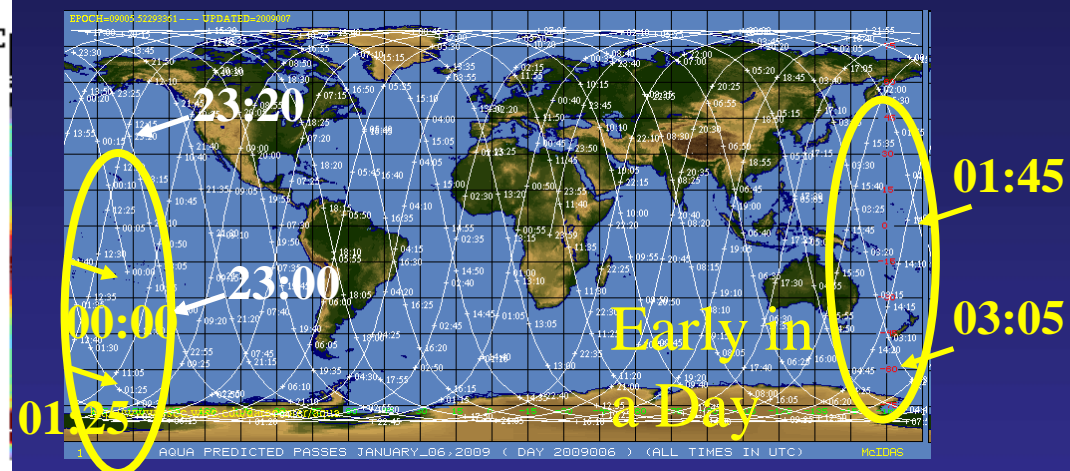
Aqua



Terra



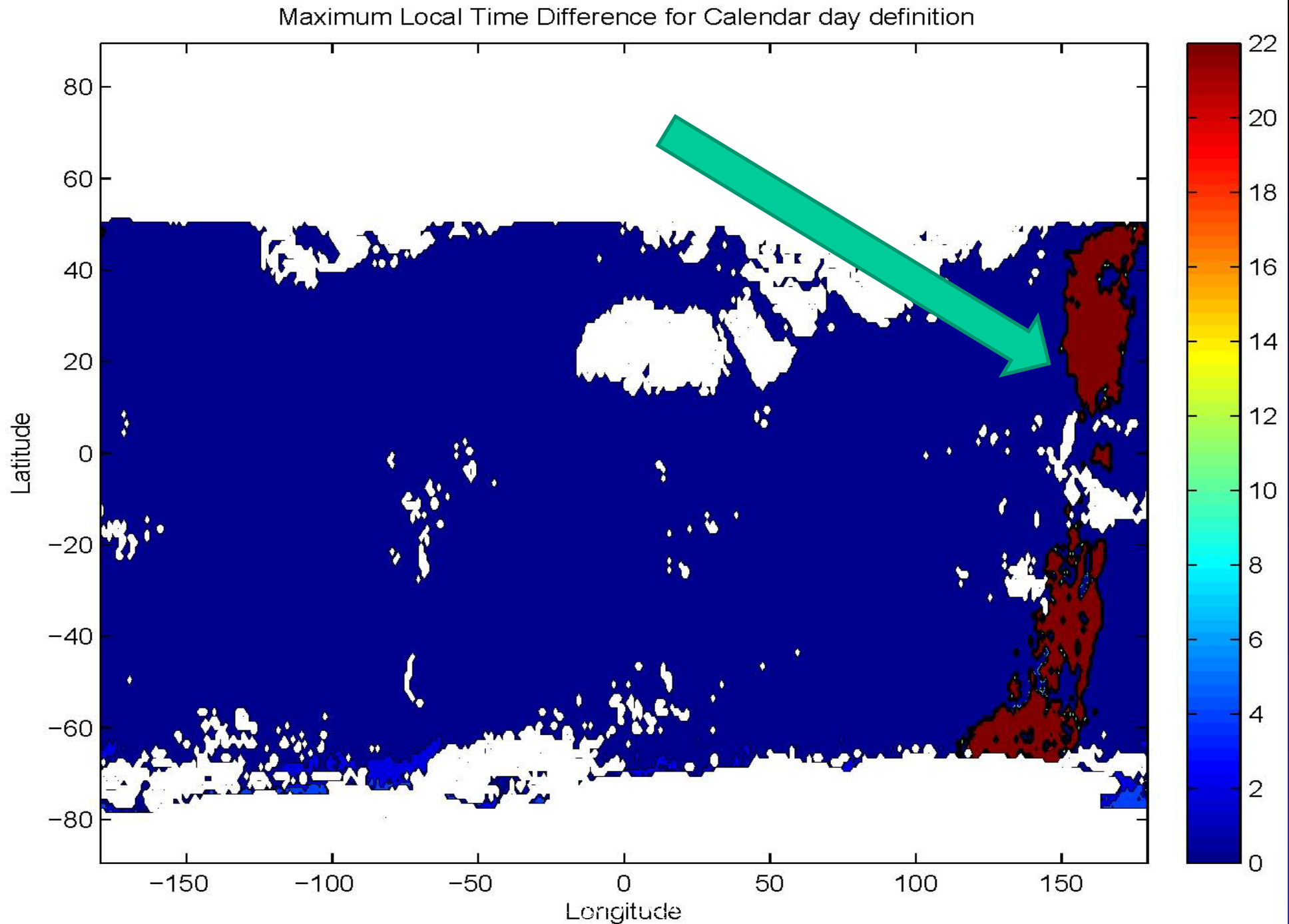
Aqua



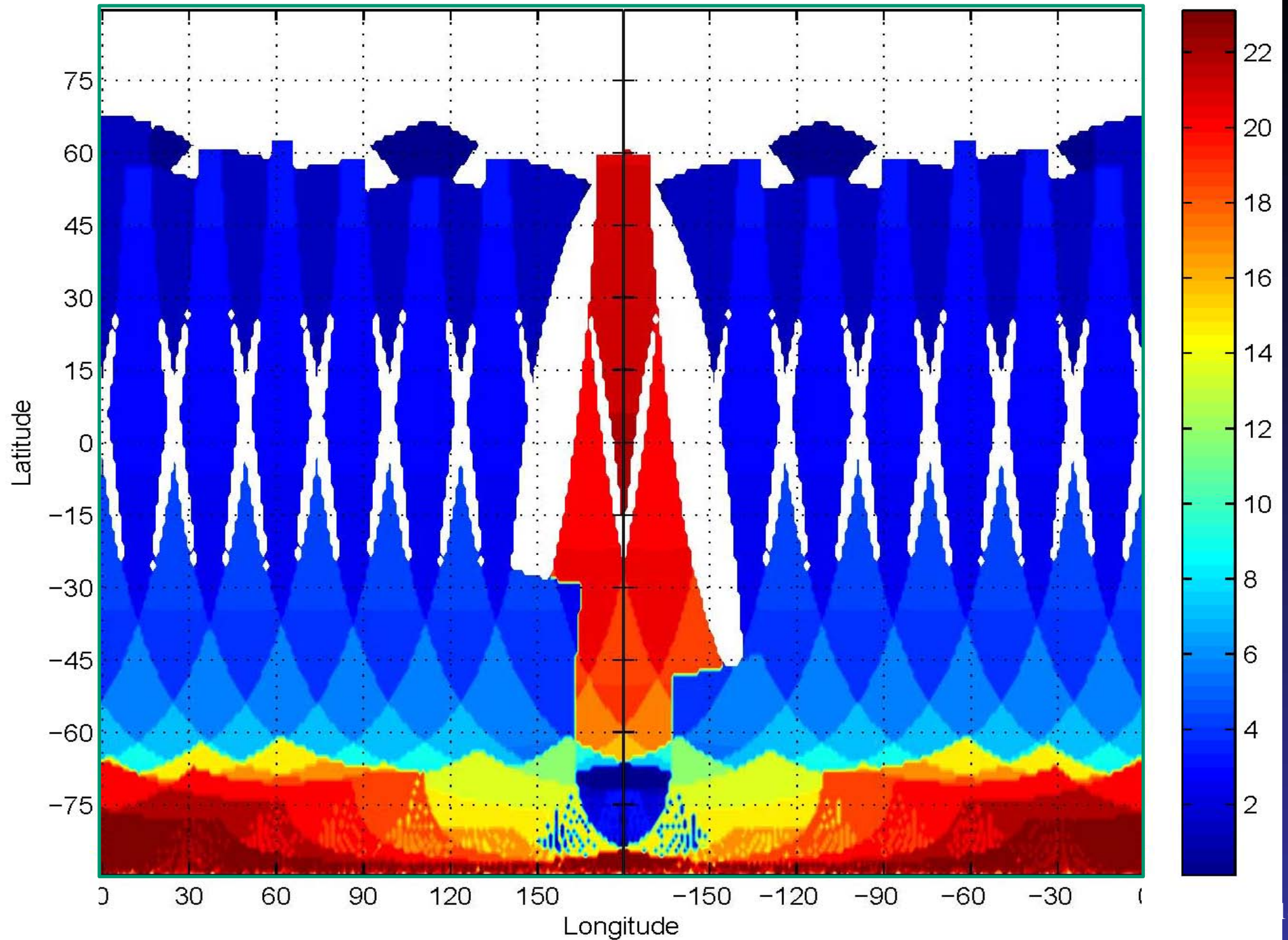
Orbit track from: <http://www.ssec.wisc.edu/datacenter>



Max Time diff. for Terra (calendar day)

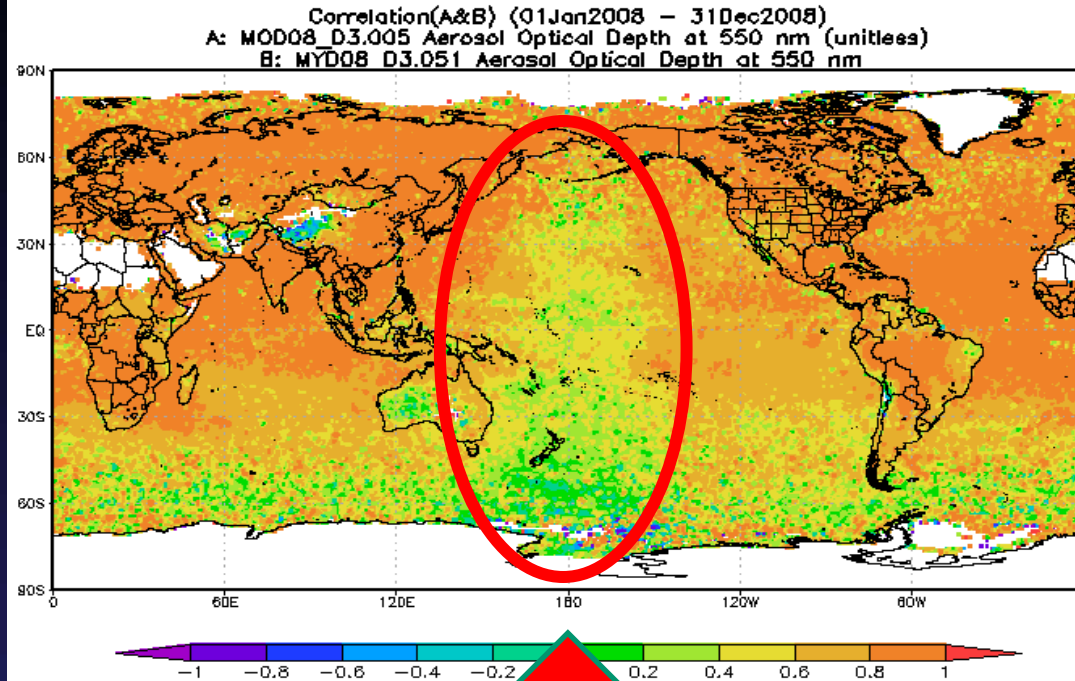


2008-01-01
Maximum time difference between Terra and Aqua

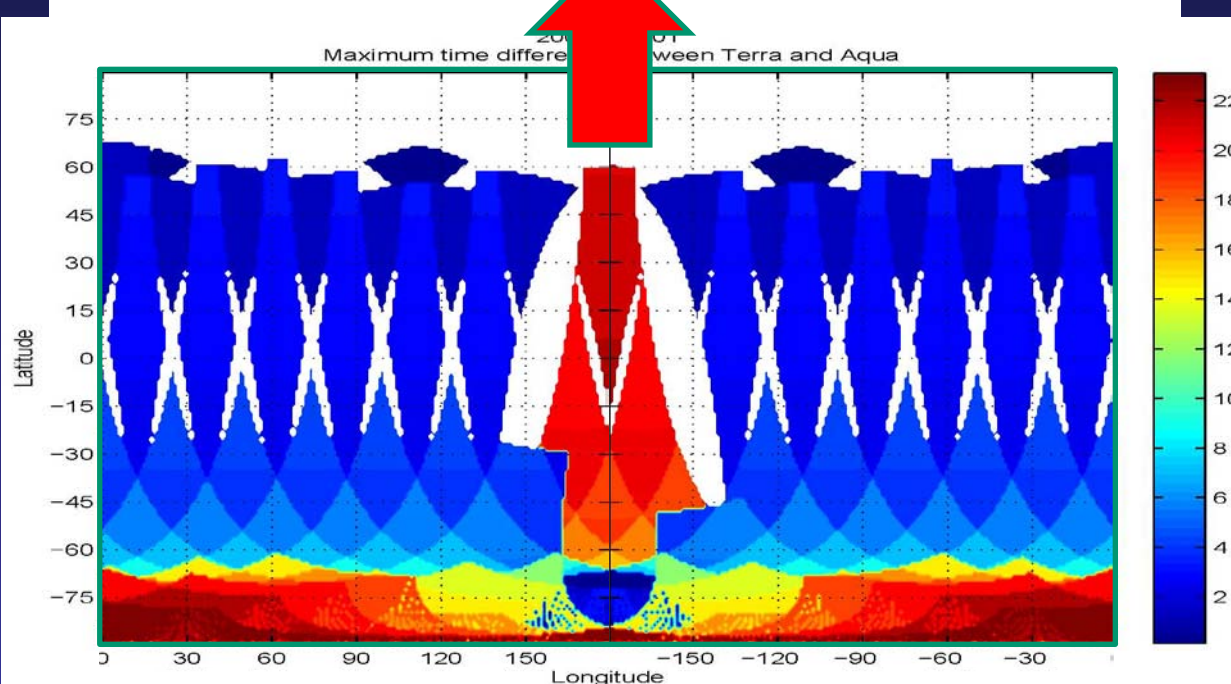




Artifact explained



Aerosols
change
sufficiently
within 22
hours to
cause
significant
drop in
correlation





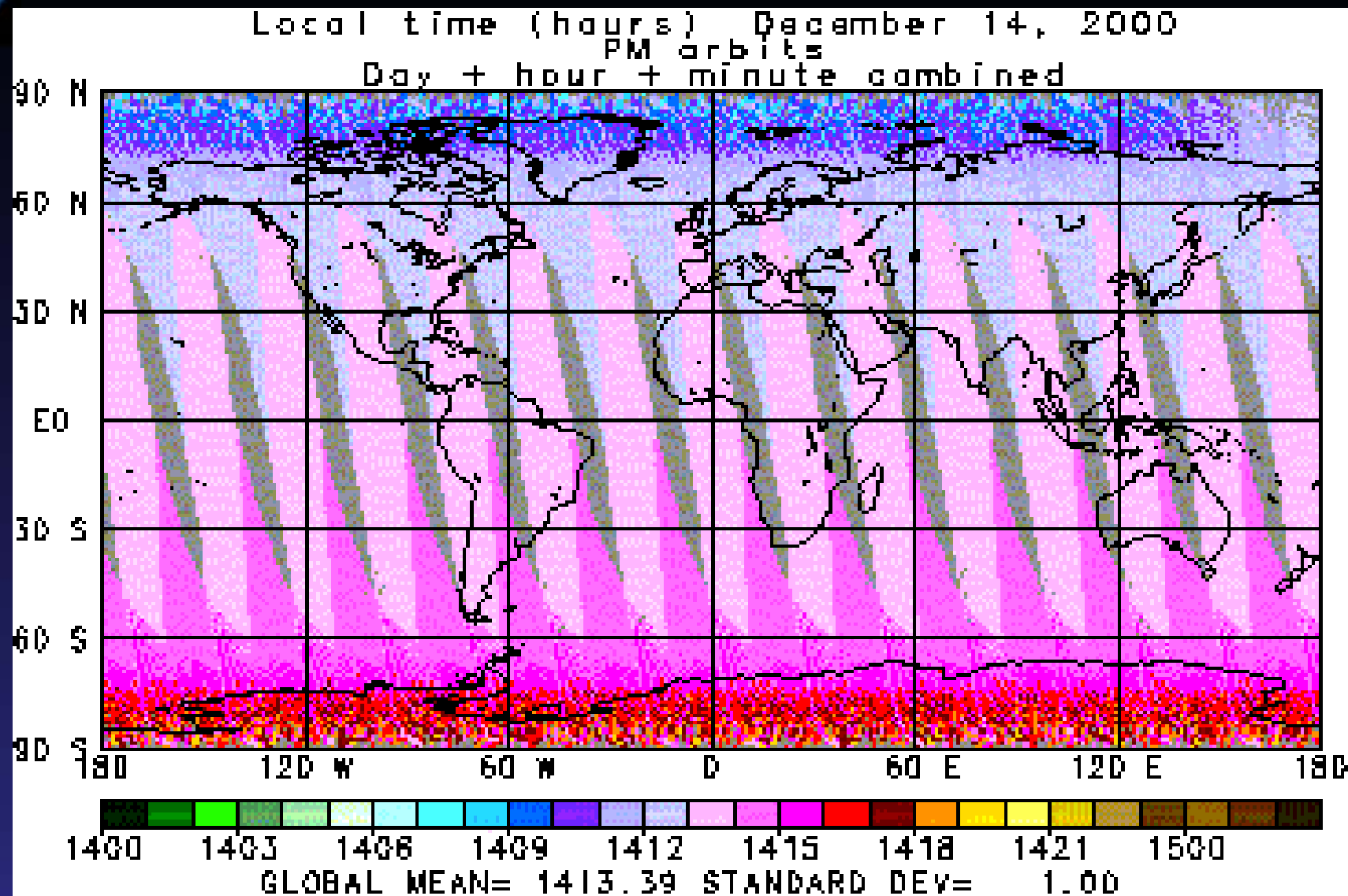
Data day definitions

OK, now we know where the artifact has come from. Is there a way to fix it, i.e., the right dataday definition?

1. Calendar dataday: all granules between 00:00 – 24:00 UTC:
MODIS Atmospheric products, OMI L2G – **problematic**
1. Local time (pixel-based): uses local date/time for each pixel
and ensures spatial continuity - **good**:
TOMS, AVHRR, AIRS, OMI, MODIS Ocean, SeaWiFS, MERIS



Local time distribution



AIRS image courtesy of L. Iredell GSFC

A sensor on sun-synchronous orbits visits every point on Earth around the same **local** (!) time, e.g., 13:30 for Aqua

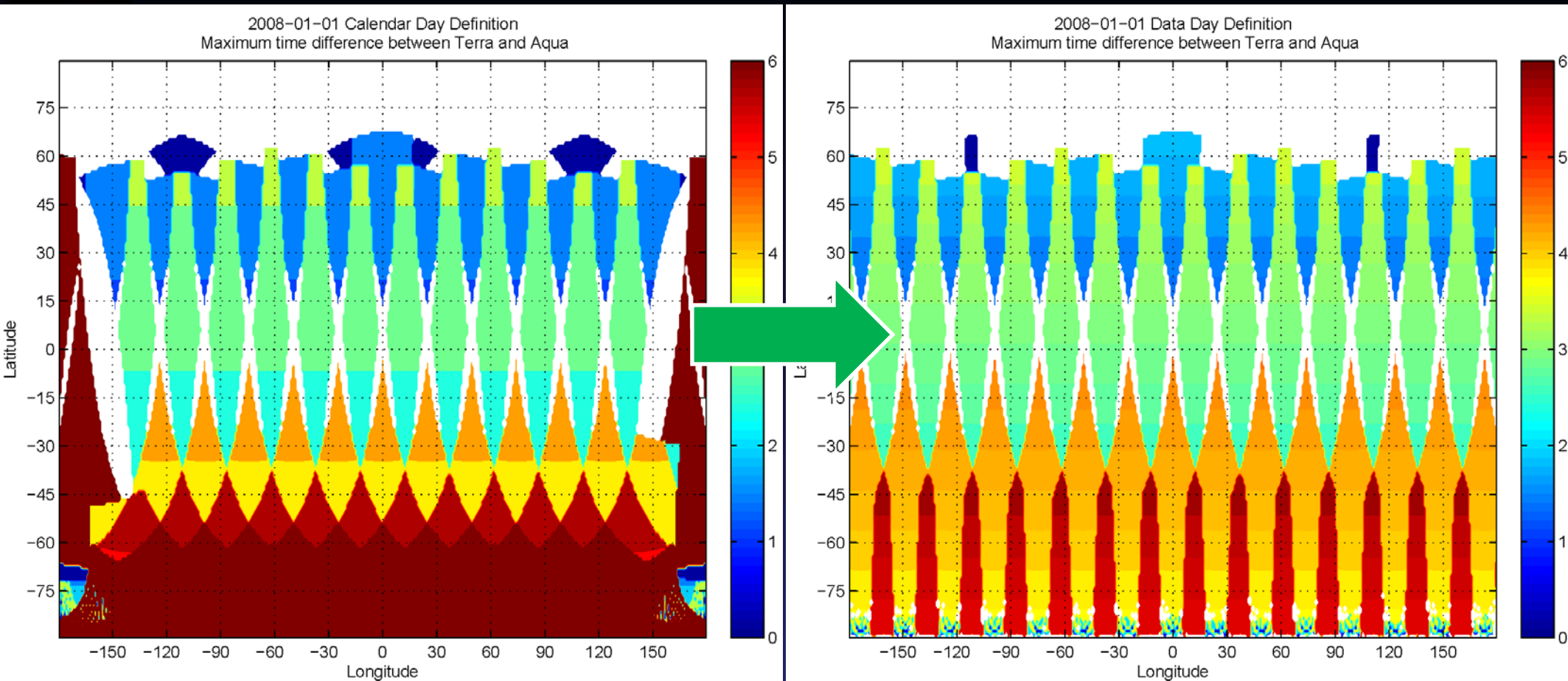


Spatial (local time) Data Day definition

- Each data set contains information for 24 hours of local time, e.g., 13:30
- The gridding starts at the dateline and progresses westward, as does the satellite
- Parts of scan lines that cross the dateline are included in the current date data set or the next, depending on which day is at the local time/day at that longitude.
- For Aqua, the p.m. orbit starts at roughly 1:30 Z on the day and ends on roughly 1:30 Z of the following day.



Max time diff. between Terra and Aqua



Calendar UTC (MODIS) dataday

Spatial (local time) dataday

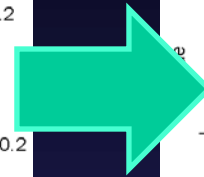
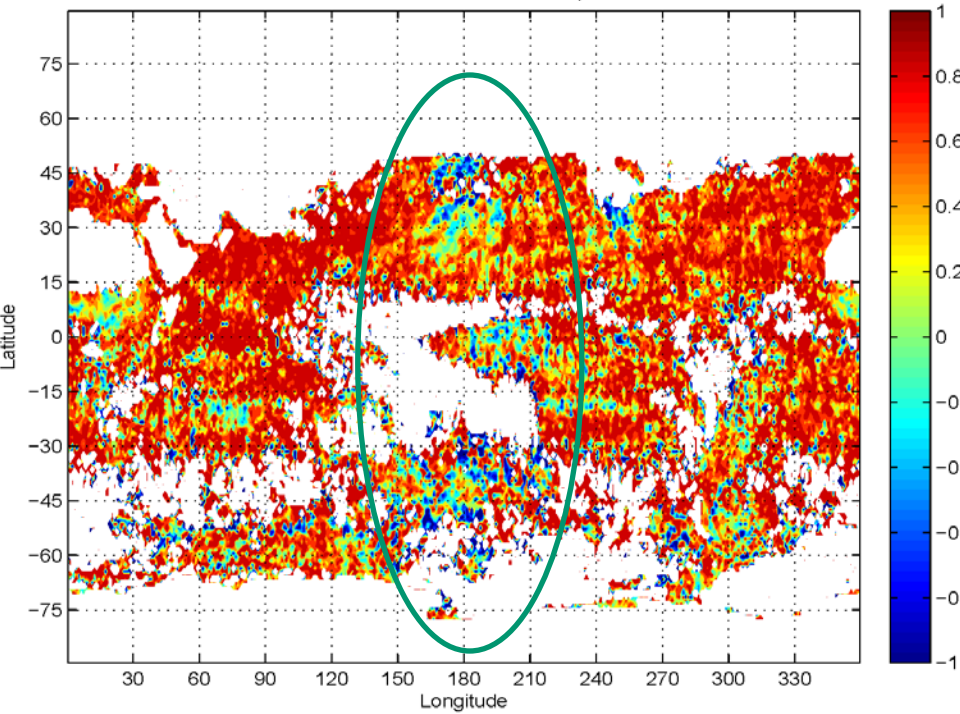
The artifact around the dateline disappears. In other areas, results are exactly the same for the (-7, 18) latitude belt.

At higher latitudes, the additional restriction for one orbit time around the local time produces different results for two dataday definitions.

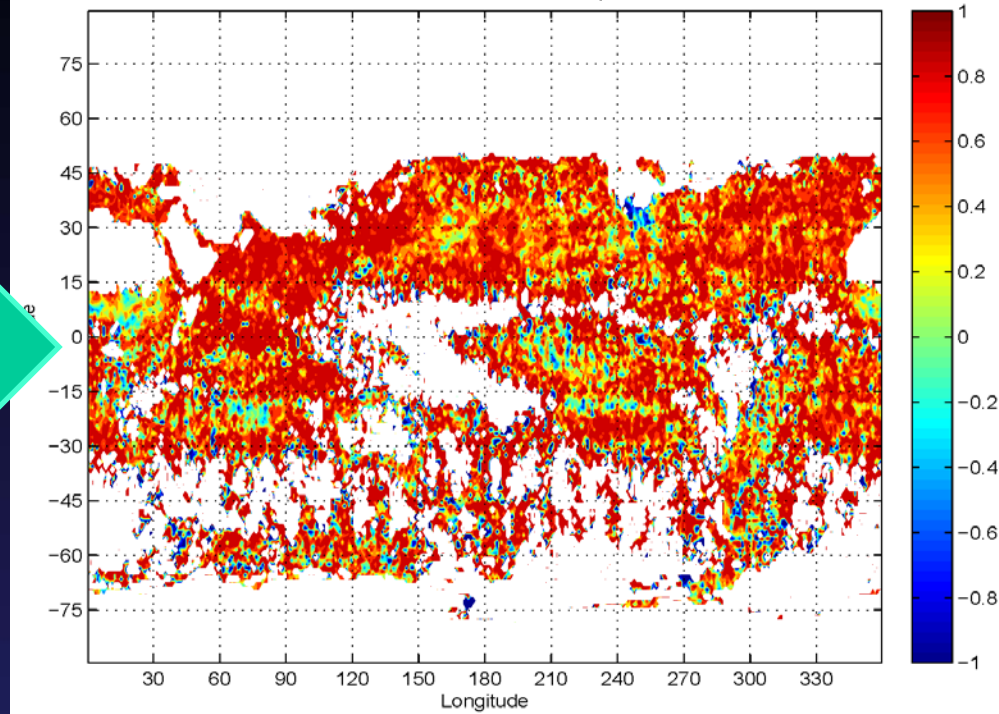


Removing the artifact in 16-day AOD correlation

2008-01-01 to 2008-01-16 Calendar Day Definition
Correlation between Terra and Aqua AOD

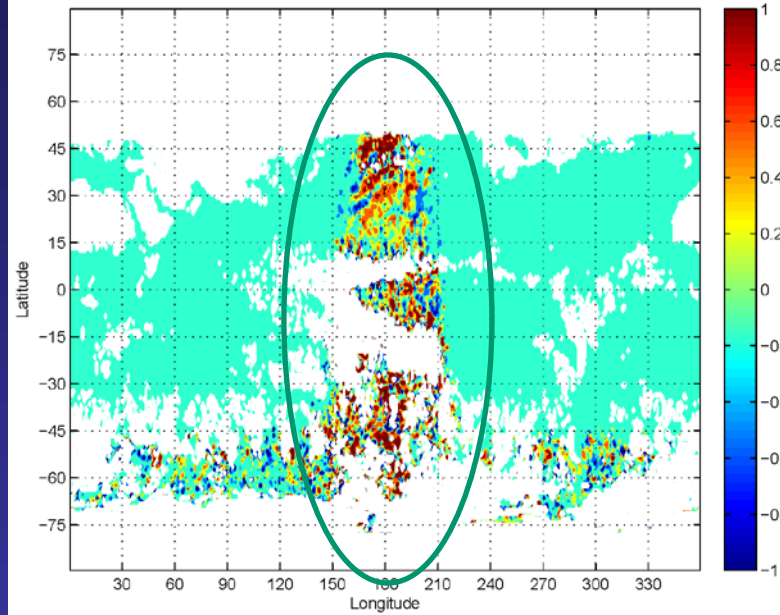


2008-01-01 to 2008-01-16 Data Day Definition
Correlation between Terra and Aqua AOD



Calendar dataday

2008-01-01 to 2008-01-16 Difference between Day Definitions
 Δ Correlation between Terra and Aqua AOD

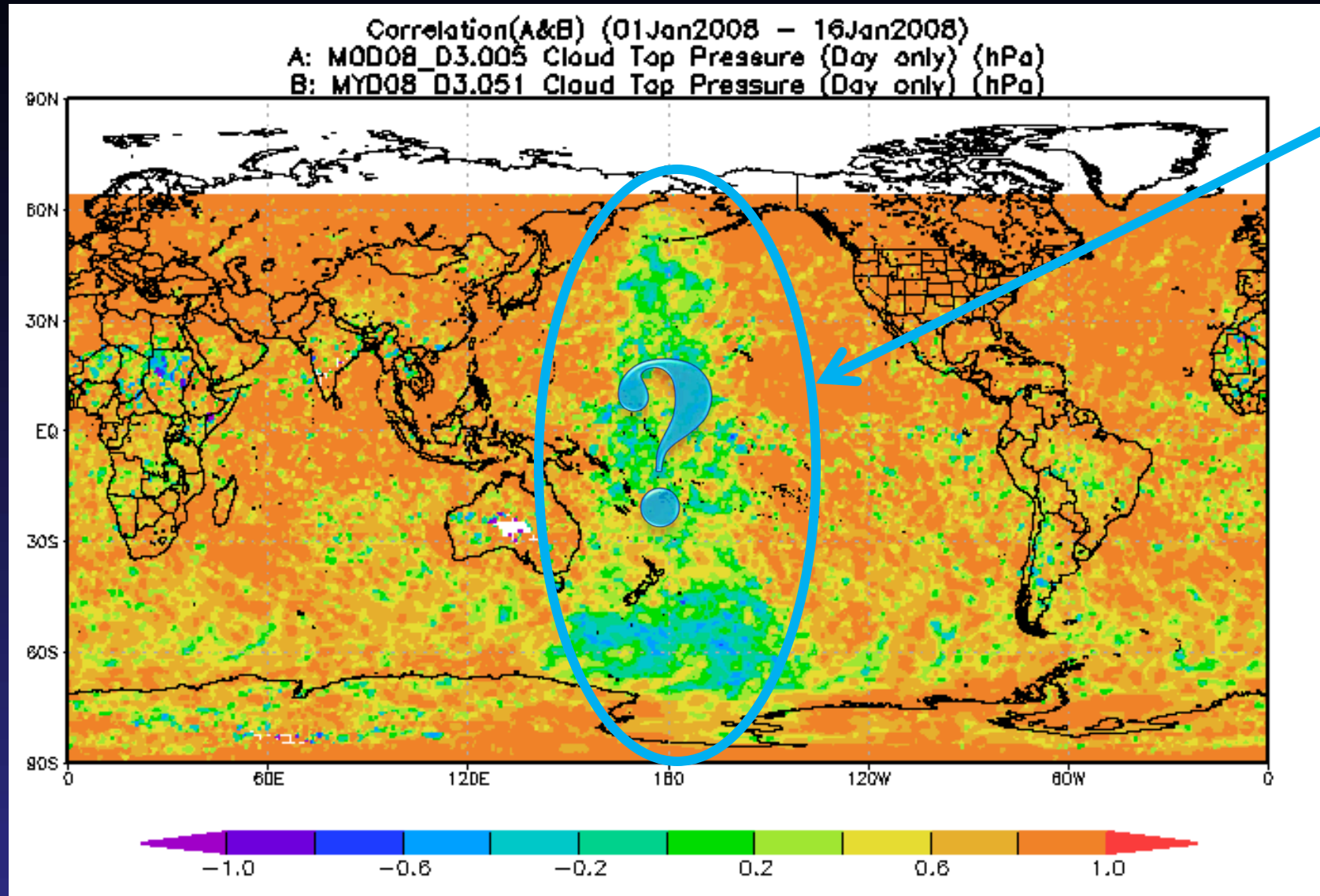


Spatial dataday

Artifact: difference between calendar and spatial dataday defs.



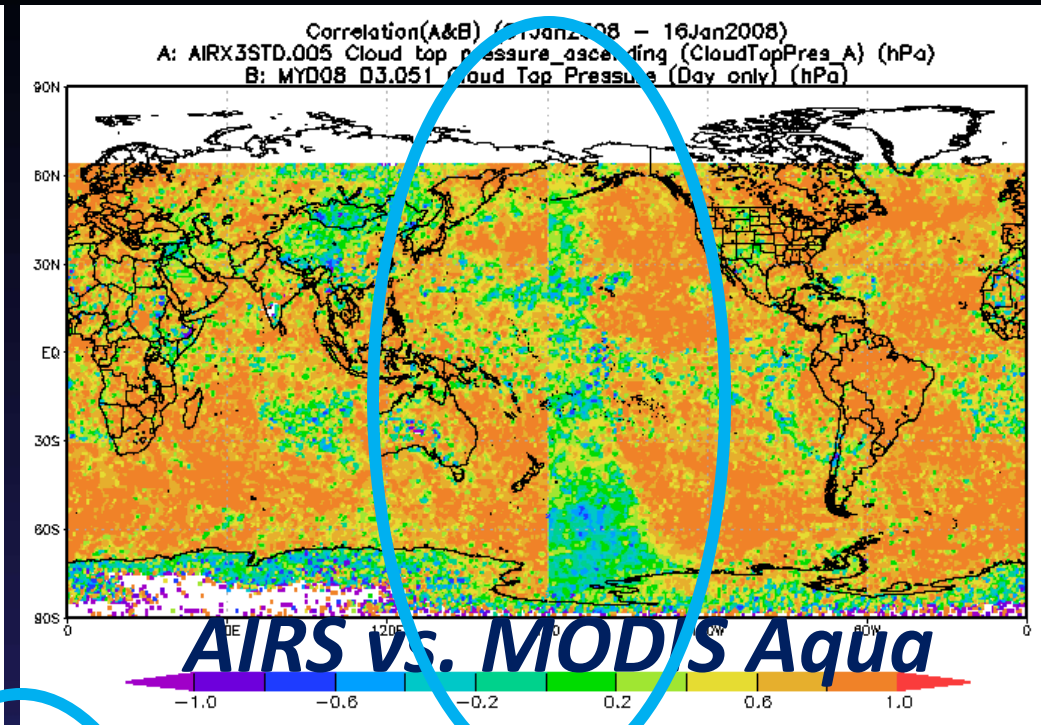
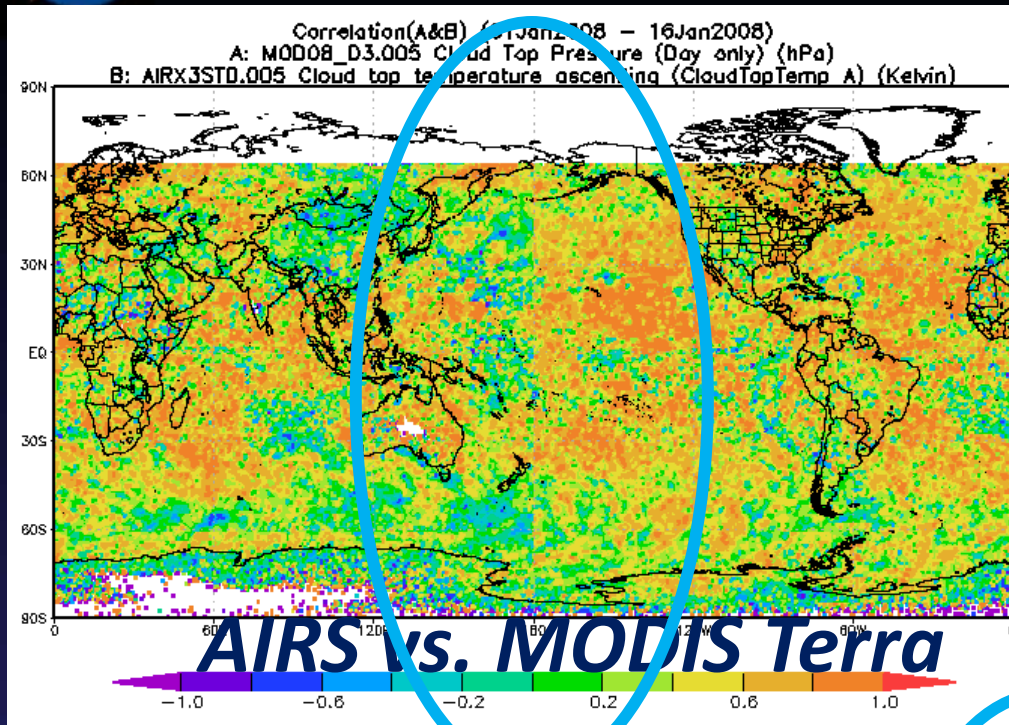
MODIS Cloud Top Pressure



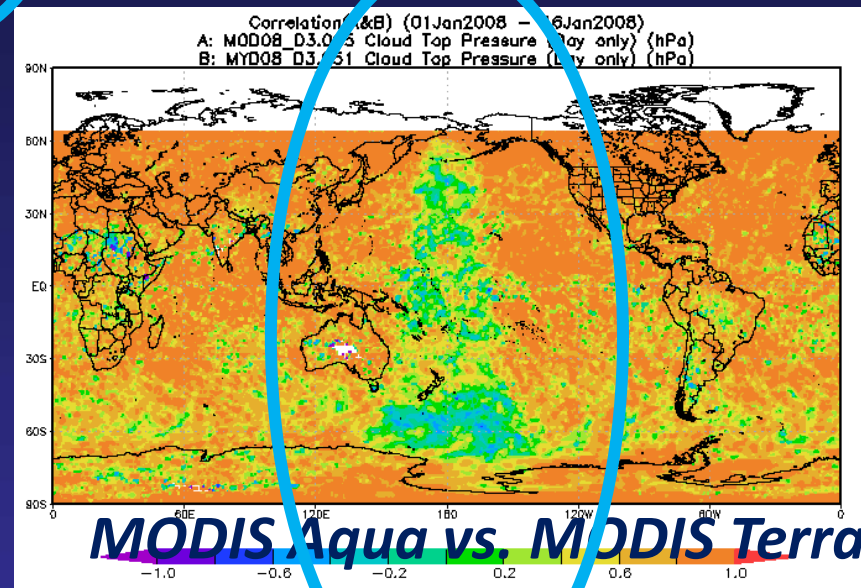
MODIS-Terra vs. MODIS-Aqua: Map of CTP temporal correlation, Jan 1-16, 2008



MODIS Terra & Aqua vs. AIRS Cloud Top Pressure



Correlation
maps for Jan
1 – 16, 2008



Different
dataday
definitions lead
to different
artifact patterns



Conclusions and recommendations

- The calendar UTC 00-24 (MODIS) dataday definition leads to artifacts around the dateline due to Δt between measurements reaching up to 23 hours
- Spatial (local-time-pixel-based) dataday definition insures consistently small Δt between measurements from different satellites, thus removing artifacts
- Different “packaging” of L2 into L3 makes a difference
- Dataday effect is just one of many sources causing differences between Level 3 products from different sensors that need to be assessed and characterized